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Final Report

R-87-10-0226

Maximizing Soil Production

Funded by
The Agriculture Development Fund

MAXIMIZING SOIL PRODUCTION

FINAL REPORT

PROJECT NO. R87-10-0226

to

SASKATCHEWAN AGRICULTURE DEVELOPMENT FUND

by

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MAXIMIZING SOIL PRODUCTION

Executive Summary

Abstract

The objectives of the project are to increase water and fertilizer use efficiency in Saskatchewan. Studies on increasing water use efficiency have focused on snow capture through stubble sculpturing and documenting evaporation losses in fall and spring. The possibility of seed-placing higher than recommended rates of urea with discers and air seeders was confirmed on soils high in clay and/or organic matter. The residual effects of high rates of P fertilization were demonstrated on alfalfa grown for forage. Residual effects of green manure lentils were highly variable. The data bases from previous projects were used to improve methods of predicting N and P fertilizer requirements. Extensive climatic and yield data bases were assembled for use in future studies.

Summary

The original objectives of the project on Maximizing Soil Production were to increase water and fertilizer use efficiency in dryland agriculture. Following discussion with Saskatchewan Agriculture and Food the emphasis of the project was shifted from side-by-side comparisons of management systems towards more interpretation of existing data.

Throughout the 3-year period investigations into snow management continued, with major emphasis on stubble sculpturing by the "clipper" attachment for swathers. On average this procedure increased available soil water supplies by 0.5 cm, indicating that relatively simple procedures can have a positive effect on the water balance. In two years of fall and spring evaporation measurements we documented substantial water losses, thus indicating the need for further investigations on how to minimize these losses.

Placing urea with the seed could reduce farmers' expenses, however, it is currently recommended that no more than 25 kg N/ha be seed-placed. On soils high in clay and/or organic matter and working with 15 farmers that used discer or air seeders, we had only one case where yield was reduced when much higher than recommended rates of urea were seed-placed. Since plant count was not affected it is likely that the decrease in yield was due to stimulation of straw growth, which left insufficient water for grain. In another case, seedling count was reduced but final grain yield was not affected by rates of seed-placed urea above 25 kg N/ha.

In two tests the residual effects of high rates of broadcast P fertilizer on alfalfa hay were demonstrated. At one site, which was deficient in P, there was an average increase of 50% in hay yield over the 3-year period. At a second site, which was slightly deficient in soil P, the yield response was observed in the last year. At both sites, P fertilization was very economical and the soil test for available P correctly predicted the P response. Small plot studies on N fertilization of winter wheat showed the superiority of spring application or a split application during the growing season over application at the fall seeding. The soil test at the time of seeding was not a good predictor of the N response of the winter wheat. In a series of field scale (40 acre) tests, no beneficial effects of green manure lentil fallow could be shown.

A number of field strip tests with presoaked seeds showed no beneficial effects on emergence or yield. The cooperating farmers reported several problems with handling the seed. The results confirm those obtained by other investigators.

The data acquired during the preceding Innovative Acres and Palliser projects was entered into easily accessible data bases. The data were used to show that response to P fertilizer was less

on stubble than on fallow (which our cooperators had suggested) and could not easily be explained by available soil P and environmental conditions. A model predicting probable crop yield as a function of spring available soil water, growing season rainfall probabilities and (soil + fertilizer)-N was developed. The model can be used to make N fertilizer recommendations for various risk (growing season rainfall) levels.

The daily climatic rainfall and temperature data for some 70 stations were acquired for the last 30 years. This data base is used to draw maps of probable precipitation, temperatures, etc. and will be used to delineate agroclimatic regions with different crop potentials. The effect of growing season rainfall distribution on yield will be assessed using the climate data base and the R.M. stubble and fallow spring wheat yields gathered by the Crop Insurance Corporation from 1973 to 1989.

Technical Report

Abstract

In accordance with its objectives, studies under the Maximizing Soil Production project over the past three years have focussed on increasing the efficiency by which water and fertilizer resources are used in Saskatchewan. Considerable emphasis was placed on managing out of season precipitation, primarily through field scale trials of stubble sculpturing for snow management, and on documenting water losses by evaporation in late fall and early spring through micrometeorological methods.

A series of 15 field strip trials with high rates of seed-placed urea were conducted. The results suggest that on soils high in clay and/or organic matter content, higher than currently recommended rates of urea can be seed-placed when the producer uses discers or air seeders. Fertilization with high rates of phosphorus showed considerable dividends for alfalfa grown for hay on soils deficient or marginally sufficient in available P. The soil test for available P correctly predicted the need for fertilizer P. One set of winter wheat trials strongly suggested that N fertilization should take place in the spring or split over the growing season, and that the soil test at time of the fall seeding was not a good predictor of N responses. The contribution of green manure lentils to the N-nutrition of the next crop could not be documented, and in the year under study (1988) yields following green manure lentil fallow were well below those of regular fallow.

Considerable time was spent analyzing data acquired during the preceding Innovative Acres and Palliser projects. The results validated farmers' opinion that the response to seed-placed P fertilizer was less on stubble than on fallow fields. A method of predicting N-fertilizer needs based on spring available soil water and growing season precipitation probabilities was developed. An extensive climatic data base (daily records of precipitation and temperature for 70 stations over a 30-year period) was acquired, as well as the R.M. fallow and stubble spring wheat yield data for the 1973-1989 period from the Crop Insurance Corporation. These data will be used to explore the relationship between growing season precipitation and yield.

Background and Objectives

The program Maximizing Soil Production was the second phase of the Innovative Acres program that was initiated in 1981. The objectives of the Innovative Acres Program were to maximize crop production through the development of water efficient, soil conserving management systems that would be practical and economical. The project was designed to demonstrate management systems that were ready to be tested in the field. Summerfallow was known to be inefficient in water conservation and to be a major factor in soil deterioration, hence much of the program focused on extending the length of the crop rotation through snow management, adequate fertilization and weed control.

Following discussions in the 1987-88 winter with personnel from Saskatchewan Agriculture and Food, it was decided that the emphasis in the program would change from side-by-side comparisons of different management systems to increased emphasis on interpretation and extension of the data that were already available. However, the main objectives of the project remained essentially unchanged: to maximize production through farming practices that most efficiently utilize water and fertilizer resources. To meet these objectives the project has cooperated with Strategic Area programs in the area of Soil Fertility, and Water Efficiency and Soil Physical Properties.

Experimental Methods

Because of the very broad nature of the objectives of this project, a number of different experiments were run during the 1987 to 1990 period. The various studies can be summarized under the following headings:

1. Studies on water management
   - 1.1 Snow management studies on 40 acre or larger fields in the winters of 1987-88, 1988-89 and 1989-90.
   - 1.2 Field scale tests on chemical fallow initiated in the summer of 1986 and completed in the summer of 1987.
   - 1.3 Field scale studies on the residual effects of legumes, initiated in 1987 and completed in 1988 (although legumes are often grown for their N_2 fixing capability, the main emphasis in these studies was on the use of Indian Head lentil as a summerfallow substitute).

2. Fertilization
   - 2.1 Field strip tests with higher than recommended rates of seed-placed urea N during the 1987, 1988 and 1989 growing seasons.
   - 2.2 Fertilization of alfalfa grown for forage at two sites using small plots during the 1987, 1988 and 1989 growing seasons.

3. Miscellaneous field tests
   - 3.1 Field strip tests on the advantages of seed soaking in the summer of 1987.
   - 3.2 Small plot tests on the N-fertilization of winter wheat, initiated in the fall of 1986 and completed in 1987.
   - 3.3 Shelterbelt planting

4. Data analysis model development and GIS
   - 4.1 Development of data bases.
   - 4.2 Data analysis.
   - 4.3 Development of models and use of geographic information systems.

Further details on those projects that were still active in this year can be found in the attached list of activities. Projects 1.2 (chemical fallow), 3.1 (seed soaking), and 3.2 (winter wheat) were described in the 1987 progress report and no detailed experimental procedure will be given here.

Results and Discussion

In this section, the results of all projects listed above will be summarized. For projects 1.1, 1.3, 2.1, 2.2, 3.3, 4.1, 4.2 and 4.3 the summary of results is basically similar to that provided in the six appended activitiy reports.

1. Water management

1.1 Snow management

A review of the earlier work conducted under the Innovative Acres program was carried out in 1987 and clearly indicated that the greatest potential for snow moisture management existed in the Gray and Gray Black soil zones. Elimination of fall tillage with the application of a herbicide (where necessary) increased snow capture and spring available water. Snow capture was further improved when the stubble was sculptured at harvest time. In the initial studies a stripper attachment was used with conventional swathers but caused a number of problems. Hence, in the last three years we have focused our attention on the clipper attachment developed by Mr. Mervin Lloyd for swathers.

In the fall of 1987, eight sites were chosen in the Brown and Dark Brown soil zones for an initial evaluation of the clipper. In each case stubble cut with the clipper was compared to even stubble in an adjacent field. Overwinter recharge in 1987-88 was quite variable with an average of 2.1 cm of snow water captured in non-stripped fields and 2.4 cm of snow water captured in stripped (clipped) fields, for an average gain of 0.3 cm by the clipper attachment. Poor snow fall and melting winter temperatures contributed to the low overwinter soil water recharge.

For the 1988-89 winter, two sites were selected in the Black soil zones. Fall and spring soil moisture were measured and a snow survey was conducted in March of 1989 before spring thaw. On average there was 15-20 cm more snow present on the clipped stubble than on the even stubble. The clipped stubble gained approximately 1.5 cm more water during the overwinter period than the even stubble, which would suggest that most but not necessarily all of the extra snow that was captured ended up as an increase in available soil water.

Three sites have been implemented for measurement over the 1989-90 winter period. Fall soil moisture measurements have been taken, but of course the measurements of spring soil moisture and of snow depth in March still remain to be taken.

1.2 Chemical fallow

The last comparison between chemical and regular fallow fields were made in the summer of 1987 at two sites in the Brown soil zone. Similar to previous tests, the results did not show any significant difference in yield between the two systems of fallow management whereas the cost for chemical fallow were considerably higher than for regular mechanical fallow. Erosion was often observed in the regular fallow fields and not in the chemical fallow fields, thus chemical fallow is definitely more soil conserving than regular fallow. Unfortunately we have no good estimates of the cost of soil erosion in terms of lost productivity and hence of the value of the soil that is being saved for future production.

1.3 Residual effects of legumes

The project was initiated in cooperation with Esso Chemicals Limited. When Esso withdrew from the project in the spring of 1988, the 1988 measurements became the sole responsibility of the project on Maximizing Soil Production. For this reason, no new trials were initiated in 1988 or 1989. In 1989, the only activity involved was the completion of the data analysis.

Unfortunately growing season conditions were very poor in 1988 and this contributed to the wide variation in the results that were obtained. Based on soil sampling in the spring of 1988 it appears that green manure lentil increased available nitrate nitrogen by about 20 kg/ha compared to wheat stubble. However, available nitrate was slightly lower (10 kg/ha) following green manure than following summerfallow. Where the lentil was grown to maturity in 1987, available nitrate nitrogen next spring was similar to that on wheat stubble. Spring available water in 1988 was similar on wheat and lentil stubble, regardless of whether the lentil was green manured early, harvested, or winter killed. Summerfallow fields contained about 6-7 cm more available water than stubble fields of wheat and lentil.

At all sites and for all treatments there was no effect of the various rates of fertilizer N that were applied in the spring of 1988, suggesting that moisture rather than nitrogen was the factor that was limiting growth on the summerfallow and various stubble fields. Hence, no benefit to the following crop from the N_2 fixed by the lentil could be demonstrated and in all cases green manuring lentil as a summerfallow substitute resulted in lower yields than regular fallow.

2. Fertilization

2.1 High rates of seed-placed urea nitrogen

In general, seed-placing more than 22 kg N/ha as urea did not adversely affect either plant stand or yield. The 22 kg N/ha rate is the currently recommended maximum rate of seed-placed urea. In 1988 at one of the sites (Kruger) seedling count decreased when urea levels were higher than 22 kg N/ha, but there were no negative effects of higher rates of seed-placed urea on yield. The only pronounced and consistent reduction in yield occurred in 1989 at the Dumonceaux site. At this site surface soil moisture at seeding was low, there was little rainfall immediately following seeding and the soil had a relatively low capacity to absorb ammonia. However, seedling count at the Dumonceaux site was not significantly affected by high rates of seed-placed urea, suggesting that toxicity was not the cause for the reduced yield. Possibly the high rates of N stimulated vegetative growth and caused moisture stress leading to the reduced grain yields.

2.2 Fertilization of forages

The initial soil sampling indicated a deficiency in P and K at the Porcupine Plain site, but only a small P deficiency and no need for K fertilizer at the Melville site. Fertilizer P recommendations for the sites were 75 and 25 kg/ha for Porcupine Plain and Melville. The level of soil test P in 1988 and 1989 reflected the amount of fertilizer P that was broadcast in 1987, but at both sites soil test P levels dropped in the third year of the trial. Soil test levels for available K did not appear to reflect the additions of K fertilizer at either site.

As predicted by the soil test, hay yield was increased with P fertilizer at the Porcupine Plain site. The alfalfa was able to utilize residual fertilizer P, thus total yield was increased by 33, 60 and 50% with the 100 kg P2O5/ha treatment in 1987, 1988 and 1989 respectively. At Melville there was no yield response to fertilizer P in 1988, but in 1989 a hay yield increase was observed. At Porcupine Plain, P fertilizer application significantly increased hay protein; at Melville, protein yield was increased in 1988. Responses to K fertilizers appeared relatively small and inconsistent at both sites.

The plots were sampled only once a year, but two cuts were actually taken by the farmers. The farmers reported that the second cuts were similar in yield to the first cuts. Hence, it was assumed that the total yield increase due to fertilizer application was twice that was measured by the single plot harvest. Calculations indicate that within the 3-year period there was a large return to the fertilizer dollar at the Porcupine Plain site. At Melville, where a yield increase occurred only in the second year, net and marginal returns were lower than at the Porcupine Plain site; however, there was still a reasonable marginal return at the 50 kg P_2O_5/ha level. Since there was no indication that the response to the original P fertilizer application was diminishing, it can be assumed that the economic return to the P fertilizer will continue to increase at both sites. It is questionable whether the investment into K fertilizer would have been economical at either site.

3. Miscellaneous

3.1 Seed soaking

The seed soaking trials were conducted by nine cooperators in 1987 as the result of farmer interest aroused by a Vancouver based company promoting this practice. The company supplied the necessary equipment and the farmers seeded the strips in fields of spring wheat, Durum, barley and red clover. Overall the results were inconclusive. In two of the strip tests seed soaking improved plant emergence and/or yield, while in another two trials seed soaking had a negative effect. In addition to this, several cooperators experienced problems with the seeding operation: heating of the seed during the dry-down period, broken kernels, poor seed flow in the seed box,

etc. The results reported here agree with those of other investigators in the same summer which show that there were no benefits associated with seed soaking.

3.2 Winter wheat

The small winter wheat plots seeded in the fall of the 1986 compared the application of nitrogen fertilizer at seeding, the next spring and a split application during the 1987 growing season. The results suggested that the nitrogen application at seeding was the least effective, followed by the nitrogen application in the spring, while the split application in general was slightly better than the spring application. However, at several sites responses to the higher rates of fertilizer nitrogen were lower than expected based on the soil test done prior to seeding in the fall of 1986. Soil testing in the spring of 1987 indicated a larger than normal increase in available nitrate, presumably since the soil sampling was done in early rather than late fall. The results would suggest that either soil sampling methods or recommendations for fertilizer nitrogen on winter wheat should take this longer mineralization period into account.

3.3 Shelterbelts

The project on Maximizing Soil Production has no direct involvement anymore with the particular site. PFRA continues to monitor tree survival and reports that there was approximately 25% loss of the Siberian larch over the 1988-89 winter. The loss is due to a combination of winter-kill and herbicide damage. The strips will be replanted with a mixture of Siberian larch and Scotch pine.

4. Data analysis

4.1 Assembly of data bases

As part of the activities of this project, we have assembled the largest existing data base in an easily accessible format. The data gathered during the previous Innovative Acres program consists of yield information (square meter yields) at specific slope positions in fields of approximately 40 farmers spread all through Saskatchewan. Information on soil water levels at seeding and harvest, an estimate of growing season precipitation at the nearby farmyard, and available nutrient levels of the field are also available. Usually at least two fields (one involving a conventional rotation and a second involving a more intensively managed rotation) were monitored during the 1982-1987 time period . A similar data base, but with less complete information on soil moisture, was gathered as part of the Palliser program that ran in the late 1970's. This data has now been stored in the same format as the Innovative Acres data.

The soil testing data base, which has restricted access, contains soil test data by quarter section for the last 5-year period. There are no yield data associated with this data base. The quarter section base prepared by the Saskatchewan Soil Survey as part of another ADF grant summarizes soil survey information, Rural Assessment data, and Crop Insurance data.

Work is continuing on updating the climate data base. We have daily climatic data (precipitation, maximum and minimum temperature and an estimate of potential evapotranspiration) for 60 sites in Saskatchewan over the last 27 years or longer. Monthly and annual climate summaries for these 60 stations are available and are being utilized by various organizations. There are an additional 12 stations for which we have complete data sets for 10 to 25 years. Data were obtained for another nine stations (two in Manitoba, four in Alberta and three in Saskatchewan) which will need minor work to become comparable in quality to the standard (1959-1987) stations. Most of the initial preparation of maps will be utilizing the information on these 60 to 70 stations. Data for an additional 78 stations that have various degrees of completeness of daily climatic records have been received, most of these will require considerable time to create reliable files. We expect that we may be able to use perhaps 30-50% of these sites.

Late in 1989 we received the Saskatchewan Crop Insurance yield data files for the 1973-1989 period. The data were received in hard copy and on magnetic tape. For each R.M. we have information for yields on summerfallow and on stubble. Statistics Canada provided us with spring wheat yield information on fallow and stubble in R.M.'s for the period from 1985-1988. Any R.M.'s with less than three farmers reporting yields were deleted by Statistics Canada. Before April we hope to do a quick comparison between spring wheat yields on summerfallow and stubble as reported by Crop Insurance and by Statistics Canada to assess the reliability of the longer and more complete Crop Insurance file.

4.2 Data analysis

The Innovative Acres, and to a lesser extent the Palliser, data bases have been used for a number of analyses. In 1987 the Innovative Acres and Palliser data base were utilized in an attempt to improve predictions of fertilizer requirements for spring wheat (the main crop in the data set). It was shown that the probability of obtaining a positive response to seed-placed phosphorus was much higher for wheat grown on summerfallow fields than for wheat grown on stubble fields. No relationship between yield response and soil available phosphorus and/or environmental conditions was evident in the data set. This led to further investigations on phosphorus availability as part of the Strategic Area program in Soil Fertility. On the other hand, responses to nitrogen fertilizer were clearly related to soil available nitrogen and available water supplies during the growing season. Classical regression analysis was not very effective in explaining the relationship,but boundary line analysis could account for up to 80% of the variability in yield. Growing season precipitation, available spring water and soil and fertilizer nitrogen are the main factors explaining yield variability. The variables are combined in a multiplicative manner. For fertilizer recommendation it is suggested that the farmer determine a probable yield level based on measured spring available moisture in combination with various levels of growing season precipitation (e.g. 25. 50 and 75% probable rainfall). As the final step, the farmer would then estimate the amount of nitrogen required to achieve this yield level.

In the use of the Innovative Acres and Palliser data bases mentioned above, the yield data for whole fields were used. The information has also been used to look at yield potential in relation to topographic position, and to generate actual and potential yield estimates for different soil landscapes. Because of the detailed information on the soil profile at each of the sampling sites, the Innovative Acres data base was used to look at the relationship between soil depth and yield in a study that was conducted with the Department of Agricultural Economics on the economic impact of soil erosion.

In the previous analyses no attempt was made at including the distribution of the growing season precipitation in the yield prediction models. Stresses late in the growing season are much more damaging to grain yields than earlier stresses which mainly result in reduced straw production. It is hoped that the combination of the climatic data base with the Crop Insurance yield data will allow us to focus on municipalities with uniform soil conditions and then to evaluate the effect of the distribution of the growing season precipitation.

4.3 Model development and geographical information systems (GIS)

Although envisaged as a major component of the new direction of the project on Maximizing Soil Production, the development of GIS systems has been slow and disappointing. This partly reflects uncertainty within the Institute as to which direction to take, and also the fact that the type of GIS systems that were envisaged are not currently available. Within the Institute, the federal Soil Survey component is concentrating on the development of 1:100,000, 1:1,000,000 and 1:2,000,000 scale inventory information systems that are compatible with the ARC/INFO system which will be used across Canada. The Soil Survey is also involved in the development of a quarter section data base which consists of a digitized soil map and also contains information from

Rural Assessment, Crop Insurance as well as growing season rainfall probabilities derived from our climate data base. In the initial proposal it was envisaged that a GIS system would be developed that could be used at the quarter section level. This system, to be developed for a microcomputer, would have much more detailed information on soil distribution, landscape features, etc. within any specific quarter and would try to make specific recommendations for that field. Predictive models would be used to assess the impact of different management strategies, for example summerfallow frequency and fertilizer practices, on yield and possibly also on quality of the soil. The development of the latter system has proven extremely difficult.

The recent addition of Dr. Pennock to our staff has added a person who has a knowledge of GIS systems. As part of his teaching mandate he will develop classes in this area and the University has supported this endeavor by buying some of the necessary computer hardware. Using this we are currently developing our capability to draw maps of climatic parameters for Saskatchewan, for example, maps of growing season precipitation and potential evapotranspiration. The next step will be to use these maps to divide Saskatchewan into a number of agroclimatic regions having different crop potential and hence having different requirements for nutrients (this work will probably be conducted as part of the Soil Fertility Strategic Area).

Conclusions and Impact

Elimination of fall tillage, and its replacement by herbicide remains by far the simplest way of increasing soil water supplies through snow management. The Innovative Acres data obtained prior to 1987 indicate that this procedure can increase soil water supplies by approximately 1 cm for stubble crops. Stubble sculpturing with the clipper attachment that is mounted on a swather on average increased soil water supplies by an additional 0.5 cm. Such simple practices could increase yields of stubble seeded spring wheat in the Brown, Dark Brown and Black soil zones by 100-150 kg/ha at little additional cost to the farmer.

In field scale trials yields on chemical fallow were similar to yields on tillage fallowed field, but the cost of chemical fallow were considerably higher than those of regular mechanical fallow. The chemical fallow did reduce erosion losses. In the drier area of the province the use of Indian Head lentil as a summerfallow substitute generally resulted in reduced yields of the next crop compared to regular fallow. Yields following a green manure fallow were similar to those following a regular stubble crop or slightly higher, but definitely below those of a regular summerfallow crop. In the summer of 1988 we could demonstrate no benefits to the following crop from the N_2 that was fixed by the lentil, clearly moisture rather than nitrogen was the factor that was limiting growth in that year. These results confirm other studies that show that in the drier areas any growth during the summerfallow year usually results in a reduced yield. Even in the usually more humid areas of the province, yield depressions did occur following a green manure legume crop although this may be the exception rather than the rule. In all areas the possible gains in soil nitrogen should be carefully balanced against the loss of crop that occurs either during the year that the green manure is grown or in the following year.

In 15 tests conducted during three quite different growing seasons, there was only one occasion where high rates of seed-placed urea resulted in a reduction in yield. In the remaining tests seed placing urea fertilizer at normal agriculture rates with air seeders and discers on soils with a high cation exchange capacity (soils high in clay and/or organic matter content) did not result in yield reductions. The cost of spreading nitrogen fertilizer in a separate operation is approximately $4.00/per acre, exclusive of labor and time. Thus, farmers that use discers and air seeders on heavy clay soils or soils high in organic matter could save themselves this expense. It is estimated that a total of approximately 8 million acres of soil would have the necessary high clay and/or organic matter content, hence a total saving of approximately $32 million might be possible. Fertilization of a second year alfalfa stand on a phosphorus deficient soil resulted in an average yield increase of 50% over the 1987, 1988 and 1989 growing season as a result of the application of 100 kg P_2O_5/ha. At a second site that was only slightly deficient in P, a response to P fertilizer

applied prior to seeding in 1987 was apparent in 1989. At both sites phosphorus levels continued to decrease over the experimental period and it is expected that the residual effect of the phosphorus will be seen for at least one more year. The project very clearly demonstrated the residual effects of high rates of broadcast phosphorus fertilizer on alfalfa stands grown for forage. Soil testing was able to predict the phosphorus response of the alfalfa, indicating that soil testing of an established alfalfa stand could be a valuable tool in detecting nutrient deficiencies. Economic responses to the P fertilizer were large and indicate the potential value of soil testing to the farmers, in particular for available phosphorus. More timely soil testing might also be of benefit in winter wheat crops. Large variations in the mineralization of organic nitrogen between seeding and the next spring appears to make it difficult to predict winter wheat responses to nitrogen fertilization. It is suggested that a nitrogen test early in the spring might be useful and cost saving. Application of the nitrogen in the spring was more effective than at seeding time.

In nine tests on seed soaking, no beneficial effects were observed while several of the farmers reported problem with handling the seed. Any expense that is associated with this practice would appear to be a waste of money.

The Innovative Acres data base was used to evaluate the effect of erosion on soil productivity. The data suggested that in the drier areas soil productivity starts to decrease once soil thickness falls below 20 cm. Attempts to start shelter belts at one of the cooperating farmers (in conjunction with PFRA) were only partly successful. Due to a combination of winter-killing and herbicide damage there was approximately 25% loss of one of the trees used.

The data gathered during the Innovative Acres program were entered into a data base and so were data from a previous program in the late 1970's. The information consists of yield data at specific slope positions, available soil moisture, growing season precipitation and a field soil fertility level. This data was used in evaluating the fertilizer requirements of spring wheat. The data indicated that responses to seed-placed phosphorus are higher and more frequent on fallow than on stubble, thus if the farmer is short of money he would be well advised to seed-place P on his summerfallow fields in preference to on his stubble fields. Responses to nitrogen fertilizer were clearly related to soil available nitrogen and available water supplies. A multiplicative boundary line analysis involving spring available soil moisture, growing season precipitation and available soil and fertilizer nitrogen explained up to 80% of the variability in yield and can be used to estimate the amount of nitrogen required to achieve various yield levels. Probable yield levels can be estimated from measurements of spring available soil moisture and probabilities of receiving certain amounts of growing season precipitation. It is expected that the findings regarding phosphorus and nitrogen responses will lead to more effective fertilizer recommendations, which would benefit the farmers and possibly the environment.

As part of the project we obtained climatic data for 60-70 stations in Saskatchewan over a 30-year period. These data will be used to estimate probabilities of growing season precipitation or probabilities of snow fall. With the data and using a simple GIS system, an attempt will be made to subdivide Saskatchewan into a large number of agroclimatic zones of different crop potential (and hence different fertilizer requirements).

Distribution of the growing season precipitation is a major variable affecting the effectiveness with which the water and nutrients are used by the crop and should be incorporated in yield prediction models. As a first step to establishing the dependence of yield on growing season rainfall distribution, we have obtained two yield data bases: the 1973-1988 R.M. yield data from the Crop Insurance Corporation and a similar 1984-1988 data set of Statistics Canada. By combining the climate information for the 60-70 stations with the 17-year Crop Insurance yield data we hope to establish the effect of rainfall distribution on yield. Once this is done we can further refine the estimates of yield levels and hence the fertilizer recommendations that should be made at different levels of probability. Such information should improve both the water and the

fertilizer use efficiencies and in the long run should leave to significant savings for the agricultural producers.

List of Papers and Talks

Bullock, P. R. and Cowell, L. 1990. High rates of seed-placed urea. Proc. Soils and Crops Workshop, Saskatoon.

Bullock, P. R. and de Jong, E. 1989. Assessing rainfall erosion risk in southern Saskatchewan from daily rainfall records. Proc. Soils and Crops Workshop, Saskatoon. I: 248-367.

de Jong, E. 1990. Water use efficiency under conservation tillage systems. Proc. Symp. Crop Management for Conservation, Yorkton. pp. 102-126.

de Jong, E. 1988. Stubble cropping: Economics and alternatives. Saskatchewan Soil Conservation Association Annual Meeting, Saskatoon, February.

de Jong, E. et al. 1988. Innovative Acres 1987 Report. S.I.P. Mimeo Report. 160 pp.

de Jong, E. et al. 1989. Innovative Acres 1988 Report. S.I.P. Mimeo Report. 88 pp.

de Jong, E. and Livingston, N. J. 1987. Snow management for grain production in Saskatchewan. Agricultural Institute of Canada Meetings, London, Ontario, August.

Flaten, P., de Jong, E. and Livingston, N. J. 1988. Yield response and economic implication of seed-placed phosphorus on stubble and summerfallow wheat and Durum. Proc. Soils and Crops Workshop, Saskatoon. II: 341-348.

Hopkins, P. R., Cowell, L. E., Brandt, S. A., Wright, A. T., Ferrie, J. and Selles, F. 1988. An evaluation of the vacuum/pressure moisturization technique for seed grains and oilseeds. Proc. Soils and Crops Workshop, Saskatoon. II: 188-193.

Rennie, D. A., de Jong, E. and Elliott, J. A. 1989. Another look at summerfallow. Sask. Soil Cons. Assoc. Annual Meeting, Swift Current, February 16.

Rennie, D. A. and de Jong, E. 1989. Innovative acres - Maintaining productivity and soil quality. AgriScience, December. pp. 5-6.

van Kooten, G. C., Weisensel, W. P. and de Jong, E. 1988. Estimating the cost of soil erosion in Saskatchewan. Annual Meeting Western Agric. Econ . Assoc., Honolulu, Hawaii, July.

van Kooten, G. C., Weisensel, W. P. and de Jong, E. 1989. Estimating the cost of soil erosion in Saskatchewan. Can. J. Agric. Econ. 37: 63-75.

Statement of Expenditures

UNIVERSITY OF SASKATCHEVAN
Agriculture Development Fund
"Maximizing Soil Production by: a) Efficient Use of Water & Fertilizers: b) Integration of Soils, Climate & Production Data in Innovative Farming Systems"
Under the Direction of E. DEJONG, SOIL SCIENCE
Statement of Receipts & Expenditures for the Period
August 1, 1989 - January 31, 1990

Receipts		
Unexpended balance as of July 31, 1989	$ 82,173.00	
Government of Saskatchevan - October, 1989	217,000.00	
Total Funds Available		$299,173.00
Expenditures		
Salaries	68,514.00	
Fringe Benefits	4,569.00	
Materials & Supplies	17,468.00	
Photocopying	194.00	
Entertainment	95.00	
Travel	15,475.00	
Equipment	1,604.00	
Equipment Maintenance	1,602.00	109,521.00
Unexpended balance as of January 31, 1990		$189,652.00

PROJECT DIRECTOR

M.G. SMITH
RESEARCH ACCOUNTANT

Projected expenditures for the period February 1 to March 31, 1990:

Salaries	$ 35,000.00
Fringe benefits	3,000.00
Materials and supplies	42,650.00
Travel	5,000.00
Equipment	37,000.00
TOTAL	$122,650.00

List of Personnel (1989/90)

	% of Time
Lyle E. Cowell	100
Jim A. Downey (summer student)	100
Kirk D. Elliott	100
Sidney G. Farkas	50
Jonathan P. Friesen (casual harvest help)	100
Emanuele Girardi (summer student)	100
Kim M. Heidinger	90
Robin P. McLeod (casual harvest help)	100
Murray E. Nielsen	100
Garth R. Parry	65
Allen A. Schrader (casual harvest help)	100
Shu R. Zhang (casual harvest help)	100

List of all equipment purchased with value in excess of $500.00 each:

2 Sprayers	$ 1,744
Laboratory oven	1,305
Bowen ratio system	11,405
Pyranometer & temperature probe	738
Apple Mac II computer	6,329
Video card for computer	547
Micrologger & enclosure, software, interface	4,053
2 each of 2MB RAM expansion kit	1,940
Sickle mower	1,604

List of equipment ordered but have not been paid by Accounts Payable as of January 31/90:

Seeder	$ 22,000
Plant grinder	3,650
Soil grinder	900
Plotter	1,700
Trailer	1,300

APPENDIX: Activities for 1989-1990

Activity 1: High rates of seed-placed urea nitrogen

Objective

To test whether it is possible to apply higher than recommended rates of seed-placed urea nitrogen when using discer or air seeders.

Experimental Procedures

Most data on maximum permissible rates of seed-placed urea nitrogen were obtained using small plot seeders. Under these conditions the average distance between the seed and the fertilizer is likely to be closer than when the nitrogen is seed-placed at higher speeds under conventional field type of operations. This would be particularly true where discer and air seeders were used. Over the 3-year period the possibility of seed placing high rates of urea nitrogen was tested at 15 sites throughout the province. Most of the soils that were tested were characterized by a high clay content and/or a high organic content as these two factors are expected to reduce the problems with seedling damage. Barley, spring wheat and Durum wheat were included in the tests which were seeded by the cooperating farmers with their own field equipment. Several rates of seed-placed urea were set out side by side including the highest rate which the farmer could apply with his seeding equipment. In most cases up to 100 kg of N/ha were applied. As part of the experimental design, additional urea was broadcast at most locations to balance the total amount of applied fertilizer nitrogen. For example, if the farmer seed-placed strips with 0, 25, 50, 75 and 100 kg N/ha, additional broadcast applications of 100, 75, 50, 25 and 0 kg N were made.

Crop measurements included seedling counts and sampling for grain yields. Surface soil samples were collected for measurement of soil properties and for measurements of available nutrients and water content. Rainfall data was collected by the cooperating farmers.

Progress and Results

In general, placing more than 22 kg N/ha as urea did not adversely affect either plant stand or yield. The 22 kg N/ha rate is the currently recommended maximum rate of seed-placed urea. In 1988 at one of the sites (Kruger) seedling count decreased when urea levels were higher than 22 kg N/ha, but there were no negative effects of higher rates of seed-placed urea on yield. The only pronounced and consistent reduction in yield occurred in 1989 at the Dumonceaux site. At this site surface soil moisture at seeding was low, there was little rainfall immediately following seeding and the soil had a relatively low capacity to absorb ammonia. However, seedling count at the Dumonceaux site was not significantly affected by high rates of seed-placed urea, suggesting that toxicity was not the cause for the reduced yield. Possibly the high rates of N stimulated vegetative growth and caused moisture stress leading to the reduced grain yields.

Conclusion

The three test years (1987, 1988 and 1989) represented a wide range of growing season conditions. The data suggest that there is little risk of seed placing urea fertilizer at normal agricultural rates with air seeders and discers on soils that are high in clay content and/or high in organic matter content. This is in contrast with seed-placement of urea using a double disc drill in which case large yield reductions may occur at low rates of seed-placed urea.

Personnel Involved	% of Time
P.R. Bullock (Strategic Area position)	15%
L.E. Cowell	30%
M.E. Nielsen (technician)	30%
K.M. Heidinger (technician)	10%
J.A. Downey (summer student)	30%
S.G. Farkas (technician)	10%
G.R. Parry (technician)	5%

Activity 2: Snow management

Objective

To increase soil moisture supplies by snow management

Experimental Procedures

During the last three winters we have concentrated on evaluating the clipper attachment for its ability to increase soil moisture supplies. The clipper attachment is mounted on the swather and leaves a strip of taller stubble about 1 m wide. The effectiveness of this form of snow management is evaluated by taking soil moisture measurements in the fall and again in the following spring. Measurements were taken for the 1987-88, 1988-89 winter and are now in progress for the 1989-90 winter period.

Progress and Results

A review of the earlier work conducted under the Innovative Acres program was carried out in 1987 and clearly indicated that the greatest potential for snow moisture management existed in the Gray and Gray Black soil zones. Elimination of fall tillage with the application of a herbicide (where necessary) increased snow capture and spring available water. Snow capture was further improved when the stubble was sculptured at harvest time. In the initial studies a stripper attachment was used with conventional swathers but led to a number of problems. Hence, in the last three years we have focused our attention on the clipper developed by Mr. Mervin Lloyd.

In the fall of 1987, eight sites were chosen in the Brown and Dark Brown soil zones for an initial evaluation of the clipper. In each case stubble cut with the clipper was compared to even stubble in an adjacent field. Overwinter recharge in 1987-88 was quite variable with an average of 2.1 cm of snow water captured in non-stripped fields and 2.4 cm of snow water captured in stripped (clipped) fields, for an average gain of 0.3 cm by the clipper attachment. Poor snow fall and melting winter temperatures contributed to the low overwinter soil water recharge.

For the 1988-89 winter, two sites were selected in the Black soil zones. Fall and spring soil moisture were measured and a snow survey was conducted in March of 1989 before spring thaw. On average there was 15-20 cm more snow present on the clipped stubble than on the even stubble. The clipped stubble gained on average 1.5 cm more water during the overwinter period than the even stubble, which would suggest that most but not necessarily all of the extra snow that was captured ended up as an increase in available soil water.

Three sites have been implemented for measurement over the 1989-90 winter period. Fall soil moisture measurements have been taken, but of course the measurements of spring soil moisture and of snow depth in March still remain to be taken.

Conclusions

Stubble management can play an important role in snow capture and water availability to the crop. The data gathered during the previous Innovative Acres project clearly supports the benefit of replacing fall tillage operations by the use of herbicides and thus leaving the stubble for snow capture. It appears that stubble sculpturing could increase the available water supplies by about 0.5 mm on average. Although this amount of water is small it could increase yields by up to 50 kg/ha or more. Thus, with a minimum of effort the farmer might be able to better manage his most limiting nutrient (water).

Personnel Involved	% of Time
P.R. Bullock (Strategic Area position)	0%
L.E. Cowell	10%
M.E. Nielsen (technician)	10%
K.M. Heidinger (technician)	10%

Activity 3: Fertilization of alfalfa grown for forage

Objective

To obtain information on the response of alfalfa grown for forage to P and K fertilizer.

Experimental Procedures

In 1987 a small split plot fertilizer experiment was laid out on a 1-year-old stand of alfalfa at Porcupine Plain. At Melville the plot was laid out in 1987 and overseeded by the farmer with alfalfa. A second plot that was laid out at Marcelin had to be abandoned because of poor stand. At each site 0-0-60 and 11-51-0 fertilizers were broadcast in a split plot design (4 blocks) to provide rates of 0, 30, 60 and 120 K_2O/ha and 0, 25, 50 and 100 kg P_2O_5/ha.

Harvest samples of hay were cut in the early bloom stage. The plots were sampled only once a year even though the farmers cut hay twice each year. Yields and protein contents were measured for the second (fall) cut at Porcupine Plain in 1987 and for the first spring cut at both sites in 1988 and 1989. Soil samples were taken before fertilizer application in 1987. At harvest in the spring of 1988 and 1989 composite soil samples were taken from the P_0 K_0, P_0 K_{30}, P_0 K_{60}, P_0 K_{120}, K_0 P_{25}, K_0 P_{50} and K_0 P_{100} plots.

Progress and Results

The initial soil sampling indicated a deficiency in P and K at Porcupine Plain, but only a small P deficiency and no need for K fertilizer at the Melville site. Fertilizer P recommendations for the sites were 75 and 25 kg/ha for Porcupine Plain and Melville. The level of soil test P in 1988 and 1989 reflected the amount of fertilizer P that was applied in 1987, but at both sites soil test P levels dropped in the third year of the trial. Soil test levels for available K did not appear to reflect the additions of K fertilizer at either site.

As predicted by the soil test, hay yield was increased with P fertilizer at the Porcupine Plain site. The alfalfa was able to utilize residual fertilizer P, thus total yield was increased by 33, 60 and 50% with the 100 kg P2O5/ha treatment in 1987, 1988 and 1989 respectively. At Melville there was no yield response to fertilizer P in 1988, but in 1989 a hay yield increase was observed. At Porcupine Plain, P fertilizer application significantly increased hay protein; at Melville, protein yield was increased in 1988. Responses to K fertilizers appeared relatively small and inconsistent at both sites.

The plots were sampled only once a year, but two cuts were actually taken by the farmers. The farmers reported that the second cuts were similar in yield to the first cuts. Hence, it was assumed that the total yield increase due to fertilizer application was twice that was measured by the single plot harvest. Calculations (Table 1) indicate that within the 3-year period there was a large return to the fertilizer dollar at the Porcupine Plain site. At Melville, where a yield increase occurred only in the second year, net and marginal returns were lower than at the Porcupine Plain site; however, there was still a reasonable marginal return at the 50 kg P_2O_5/ha level. Since there was no indication that the response to the original P fertilizer application was diminishing, it can be assumed that the economic return to the P fertilizer will continue to increase at both sites. It is questionable whether the investment into K fertilizer would have been economical at either site.

Table 1. Economic return to P fertilizer application

Site	Treatment	Yield increase[1] (kg/ha)	Net return[2] ($/ha)	Marginal return[3]
Porcupine Plain	P25	1364	64	4.5
	P50	3524	175	5.9
	P100	5040	230	4.2
Melville	P25	560	15	1.9
	P50	1198	36	2.0
	P100	1374	10	1.1

[1] Total yield increase for 3 years at Porcupine Plain and 2 years at Melville: assumes two harvests per year.
[2] Value of hay yield increase less fertilizer cost (hay $60/tonne, P_2O_5 $0.70/kg, K_2O $0.18/kg).
[3] Marginal return = Value of increased yield/cost of fertilizer input.

Conclusions

The project demonstrated that P fertilizers obviously have residual value beyond the year of application when broadcast at high rates on alfalfa grown for forage. Soil P analysis was able to predict phosphorus deficiencies and fertilizer requirements for alfalfa, but the same could not be said for analysis for soil available K. Economic responses to fertilizer P were large and persisted throughout the 3-year trial. The data also suggested that the soil testing of an established alfalfa rotation could be a valuable tool in detecting nutrient deficiencies.

Personnel Involved	% of Time
L.E. Cowell	10%
M.E. Nielsen (technician)	15%
J.A. Downey (summer student)	10%
S.G. Farkas (technician)	10%
G.R. Parry (technician)	5%

Activity 4: Residual effect of lentils on succeeding wheat yield

Objectives

To investigate the effect of green manure lentil on the yield of subsequent wheat crops.

Experimental Procedure

In 1987, wheat, Laird lentil and green manure (Indian Head) lentils were grown by seven cooperating farmers. A summerfallow treatment was included at five sites. In the spring of 1988 wheat was planted on all fields and nitrogen applied at 0, 25, 50 and 75 kg/ha. Yield and soil samples were collected from the various plots.

Progress and Results

The project was initiated in cooperation with Esso Chemicals Limited. When Esso withdrew from the project in the spring of 1988, the 1988 measurements became the sole responsibility of the project on Maximizing Soil Production. For this reason, no new trials were initiated in 1988 or 1989. Hence, in 1989 the only activity involved was the completion of the data analysis.

Unfortunately growing season conditions were very poor in 1988 and this contributed to the wide variation in the results that were obtained. Based on soil sampling in the spring of 1988 it appears that green manure lentil increased available nitrate nitrogen by about 20 kg/ha compared to wheat stubble. However, available nitrate was slightly lower (10 kg/ha) following green manure than following summerfallow. Where the lentil was grown to maturity in 1987, available nitrate nitrogen next spring was similar to that on wheat stubble. Spring available water in 1988 was similar on wheat and lentil stubble, regardless of whether the lentil was green manured early, harvested, or winter killed. Summerfallow fields contained about 6-7 cm more available water than stubble fields of wheat and lentil.

At all sites and for all treatments there was no effect of the various rates of fertilizer N that were applied in the 1988 spring, suggesting that moisture rather than nitrogen was the factor that was limiting growth on the summerfallow and various stubble fields. Hence, no benefit to the following crop from the N_2 fixed by the lentil could be demonstrated.

Conclusions

Lack of spring moisture and precipitation in 1988 overshadowed any affect of the previous crop. Green manuring lentil in 1987 as a summerfallow substitute resulted in lower 1988 yields than regular summerfallow. At two of the five sites that were harvested, wheat on green manure lentil yielded better than wheat on wheat. The data confirm that the benefits of legumes in rotations are difficult to document in the drier parts of the province.

Personnel Involved

	% of Time
C. van Kessel (Strategic Area Soil Fertility)	5%
N.J. Livingston	5%

Note: The times above are those spent in 1989 in preparing the final report.

Activity 5: Shelterbelts

Objective

To demonstrate the value of shelterbelts on soils that are subject to wind erosion.

Experimental Procedures

Wind erosion has been a problem on the Butler farm at Marcelin. In 1987, the project cooperated with PFRA in planting of shelterbelts in one field using Siberian larch, green ash and caragana. The Siberian larch was planted in the fall of 1987 and second planting in the spring of 1988.

Progress and Results

The project on Maximizing Soil Production has no direct involvement anymore with the particular site. PFRA continues to monitor tree survival and reports that there was approximately 25% loss of the Siberian larch over the 1988-89 winter. The loss is due to a combination of winter-kill and herbicide damage. The strips will be replanted with a mixture of Siberian larch and Scotch pine.

Conclusions

None at present.

Personnel Involved

None

Activity 6: Data analysis, model development and GIS

Objective

To develop computer assisted methods of utilizing soils and crop information.

Experimental Procedures

Considerable yield information has been gathered during various field programs of the Saskatchewan Institute of Pedology. Much of this information is field specific and must be extended by using soil and climate data. Also, yield data from other sources should be utilized. It is expected that this integration of various data bases can be accomplished most effectively using a Geographic Information System and crop production modelling.

Progress and Results

1. Available data bases: As part of the activities of this project, we have assembled some of the existing data bases in an easily accessible format. The data gathered during the previous Innovative Acres program consists of yield information (square meter yields) at specific slope positions in fields of approximately 40 farmers spread all through Saskatchewan. Information on soil water levels at seeding and harvest, an estimate of growing season precipitation at the nearby farmyard, and an estimate of field available nutrient levels are also available. Usually at least two fields (one involving a conventional rotation and a second involving a more intensively managed rotation) were monitored. This data base covers the time period 1982-1987. A similar data base, but with less complete information on soil moisture, was gathered as part of the Palliser program that ran in the late 1970's. This data has now been stored in the same format as the Innovative Acres data.

The soil testing data base, which has restricted access, contains soil test data by quarter section for the last 5-year period. There are no yield data associated with this data base. The quarter section base prepared by the Saskatchewan Soil Survey as part of another ADF grant summarizes soil survey information, Rural Assessment data, and Crop Insurance data.

Work is continuing on updating the climate data base. We have daily climatic data (precipitation, maximum and minimum temperature and an estimate of potential evapotranspiration) for 60 sites in Saskatchewan over the last 27 years or longer. Monthly and annual climate summaries for these 60 stations are available and are being utilized by various organizations. There are an additional 12 stations for which we have complete data sets for 10 to 25 years. Data were obtained for another nine stations (two in Manitoba, four in Alberta and three in Saskatchewan) which will need minor work to become comparable in quality to the standard (1959-1987) stations. Most of the initial preparation of maps will be utilizing the information on these 60 to 70 stations. Data for an additional 78 stations that have various degrees of completeness of daily climatic records have been received . Most of these 78 stations will require considerable time to create reliable files. We expect that we may be able to use perhaps 30-50% of these sites.

Late in 1989 we received the Saskatchewan Crop Insurance yield data files for the 1973-1989 period. The data were received in hard copy and on magnetic tape. For each R.M. we have information for yields on summerfallow and on stubble. Statistics Canada provided us with spring wheat yield information on fallow and stubble in R.M.'s for the period from 1985-1988. Any R.M.'s with less than three farmers reporting yields were deleted by Statistics Canada. Before April we hope to do a quick comparison between the spring wheat yields on summerfallow and stubble as reported by Crop Insurance and by Statistics Canada to assess the reliability of the longer and more complete Crop Insurance file.

2. Data analysis: The Innovative Acres, and to a lesser extent the Palliser, data bases have been used for a number of analyses. In 1987 the Innovative Acres and Palliser data base were utilized in an attempt to improve predictions of fertilizer requirements on crops. It was shown that the probability of obtaining a positive response to seed-placed phosphorus was much higher for wheat grown on summerfallow fields than wheat grown on stubble fields. This led to further investigations on phosphorus availability as part of the Strategic Area program in Soil Fertility. No relationship between yield response and soil available phosphorus and/or environmental conditions was evident in the data set. On the other hand, responses to nitrogen fertilizer were clearly related to soil available nitrogen and available water supplies during the growing season. Classical regression analysis was not very effective in explaining the relationship,but boundary line analysis could account for up to 80% of the variability in yield. Growing season precipitation, available spring water and soil and fertilizer nitrogen are the main factors explaining yield variability. The variables are combined in a multiplicative manner. For fertilizer recommendation it is suggested that the farmer determine a probable yield level based on measured spring available moisture in combination with variable levels of growing season precipitation. As the final step, the farmer would then estimate the amount of nitrogen required to achieve this yield level.

In the use of the Innovative Acres and Palliser data bases mentioned above, the yield data for whole fields were used. The information has also been used to look at yield potential in relation to topographic position, and to generate yield estimates for different soil landscapes. Because of the detailed information on the soil profile at each of the sampling sites, the Innovative Acres data base was used to look at the relationship between soil depth and yield in a study that was conducted with the Department of Agricultural Economics on the economic impact of soil erosion.

In the previous analyses no attempt was made at including the distribution of the growing season precipitation in the yield prediction models. Stresses late in the growing season are much more damaging to grain yields than earlier stresses which mainly result in reduced straw production. It is hoped that the combination of the climatic data base with the Crop Insurance yield data will allow us to focus on municipalities with uniform soil conditions and then to evaluate the effect of growing season precipitation distribution.

3. Geographical Information Systems (GIS): Although envisaged as a major component of the new direction of the project on Maximizing Soil Production, the development of GIS systems has been slow and disappointing. This partly reflects uncertainty within the Institute as to which direction to take, and also the fact that the type of GIS systems that were envisaged are not currently available. Within the Institute, the federal Soil Survey component is concentrating on the development of 1:100,000 (and smaller) scale inventory information system that is compatible with the ARC/INFO system which will be used for large map units across Canada. The Soil Survey is also involved in the development of a quarter section data base which consists of a digitized soil map and also contains information from Rural Assessment, Crop Insurance as well as growing season rainfall probabilities derived from our climate data base. In the initial proposal it was envisaged that a GIS system would be developed that could be used at the quarter section level. This system, to be developed for a microcomputer, would have much more detailed information on soil distribution, landscape features, etc. within any specific quarter and would try to make specific recommendations for that field. Predictive models would have to be used to assess the impact of different management strategies, for example fertilizer practices, on yield and possibly also on quality of the soil. The development of the latter system has proven extremely difficult.

The recent addition of Dr. Pennock to our staff has added a person who has a knowledge of GIS systems. As part of his teaching mandate he will develop classes in this area and the University has supported this endeavor by buying some of the necessary computer systems. Using these we are currently developing our capability to draw maps of climatic parameters for Saskatchewan, for example, maps of growing season precipitation and potential evapotranspiration. The next step will be to use these maps to divide Saskatchewan into a number

of agroclimatic regions having different crop potential and hence having different requirements for nutrients (this work will probably be conducted as part of the Soil Fertility Strategic Area).

Conclusion

During the last three years a number of data bases have been assembled that can be used to relate yield to environmental parameters. In addition, the climate data base can easily be accessed and the same will be true for the R.M. yield data base for spring wheat on fallow and stubble. Several potential users have expressed interest in using the climate data base or have already done so, either using the raw data or getting processed information such as probabilities of snow fall (for snow management studies) or growing season precipitation.

Personnel Involved

	% of Time
P.R. Bullock	25%
D.J. Pennock	10%
K.M. Heidinger (technician)	50%
J.R. Bettany	10%